

METHODS AND APPARATUS FOR FABRICATING GAS TURBINE ENGINE COMBUSTORS

BACKGROUND OF THE INVENTION

[0001] This application relates generally to gas turbine engines and, more particularly, to combustors for gas turbine engine.

[0002] Combustors are used to ignite fuel and air mixtures in gas turbine engines. Known combustors include at least one dome attached to a combustor liner that defines a combustion zone. Fuel injectors are attached to the combustor in flow communication with the dome and supply fuel to the combustion zone. Fuel enters the combustor through a dome assembly attached to a spectacle or dome plate.

[0003] At least some known dome assemblies include an air swirler that is secured to the dome plate, and is radially outward from a venturi. The venturi is divergent and facilitates mixing the air and fuel, and spreading the mixture radially outwardly into the combustion zone.

[0004] To facilitate nitrous oxide (NO_x) abatement, water is injected into at least some known gas turbine engine combustors. However, continued operation with water injection may cause material degradation and/or erosion of the combustor venturi. More specifically, because the water and fuel are typically sprayed through the combustor venturi, as the water contacts the venturi, the high operating temperatures of the water may cause the water to quickly change from a liquid to steam in an effect known as "explosive boiling". Over time, such explosive boiling may lead to material degradation and/or removal at the point of impact between the water and the venturi. To facilitate reducing the effects of the water injection, at least some known combustor venturis are coated with a ceramic coating. Although such coatings may decrease the effect of the water injection, such coatings also increase the fabrication time and costs.

BRIEF SUMMARY OF THE INVENTION

[0005] In one embodiment, a method for fabricating a gas turbine engine combustor is provided. The method comprises coupling a venturi to a primary swirler, and coupling the venturi to a secondary swirler such that a gap is defined between a portion of the venturi and a portion of one of the primary swirler and the secondary swirler.

[0006] In another embodiment, a combustor for a gas turbine engine is provided. The combustor includes a venturi and a secondary swirler extending circumferentially around the venturi. The secondary swirler is coupled to the venturi such that a gap is defined between a portion of the secondary swirler and the venturi.

[0007] In a further embodiment, a gas turbine engine is provided. The gas turbine engine includes a combustor including at least one annular air swirler and an annular venturi. The annular air swirler is coupled to the venturi such that a gap is defined between a portion of the air swirler and the venturi.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a schematic illustration of a gas turbine engine;

[0009] Figure 2 is a cross-sectional view of a portion of a combustor that may be used with the gas turbine engine shown in Figure 1; and

[0010] Figure 3 is a cross-sectional view of a portion of an alternative embodiment of a combustor that may be used with the gas turbine engine shown in Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Figure 1 is a schematic illustration of a gas turbine engine 10 including a low pressure compressor 12, a high pressure compressor 14, and a combustor 16. Engine 10 also includes a high pressure turbine 18 and a low pressure turbine 20. Combustor 16 includes an upstream side 22, and at least one dome (not

shown). In one embodiment, the gas turbine engine is a LMS 100 engine commercially available from General Electric Company, Cincinnati, Ohio.

[0012] In operation, air flows through low pressure compressor 12 and compressed air is supplied from low pressure compressor 12 to high pressure compressor 14. The highly compressed air is delivered to combustor 16. Airflow (not shown in Figure 1) from combustor 16 drives turbines 18 and 20.

[0013] Figure 2 is a cross-sectional view of a portion of a combustor, such as combustor 16, that may be used with gas turbine engine 10. Combustor 16 includes a plurality of swirler assemblies 30, each of which includes a primary swirler 32, a secondary swirler 34, and a venturi 36 that is coupled to primary and secondary swirlers 32 and 34, respectively. Primary swirler 32, secondary swirler 34, and venturi 36 are each co-axially aligned with an axial centerline 38 of swirler assembly 30.

[0014] Primary swirler 32 includes a substantially cylindrical body 40 defined by an outer perimeter 42, an inner surface 44, and an outer surface 46. A radial opening 48 extends between inner and outer surfaces 44 and 46, respectively. Outer surface 46 faces upstream, and inner surface 44 faces downstream when primary swirler 32 is coupled within combustor 16. A plurality of swirl vanes 50 extend circumferentially around opening 48 and extend between inner surface 44 and venturi 36. In an alternative embodiment, swirl vanes 50 extend between a radially outer, or upstream, wall 52 and a radially inner, or downstream, wall (not shown). In the exemplary embodiment, primary swirl vanes 50 are spaced equidistantly apart and are oriented to induce a swirling action to a fuel/air mixture passing through swirler assembly 30.

[0015] Secondary swirler 34 includes an inner wall 60, an outer wall 62, and a flow passage 64 extending therebetween. In the exemplary embodiment, secondary swirler 34 is a two-piece assembly including inner wall 60 and outer wall 62. Alternatively, secondary swirler 34 may be an integrally-formed single piece assembly. Flow passage 64 has an upstream end 66 and a downstream end 68. Inner and outer walls 60 and 62, respectively, extend circumferentially around axial

centerline 38 of swirler assembly 30. A flange portion 70 of secondary swirler 34 extends a distance 72 radially outward from flow passage upstream end 66, such that an outer perimeter 74 of flange portion 70 is substantially aligned with primary swirler outer perimeter 42. Flange portion 70 is in flow communication with flow passage 64 such that air is supplied to flow passage 64 through flange portion 70.

[0016] A plurality of swirl vanes 80 extend from an inner surface 82 of outer wall 62 to an inner surface 84 of inner wall 60. In the exemplary embodiment, inner and outer walls 60 and 62, respectively, are coupled together by brazing or welding secondary swirl vanes 80 to inner wall 60. In an alternative embodiment, outer wall 62 and inner wall 60 are formed integrally together and secondary swirl vanes 80 extend therebetween. In the exemplary embodiment, secondary swirl vanes 80 are spaced equidistantly apart and are oriented to induce a swirling action to air channeled through flow passage 64. In the exemplary embodiment, primary and secondary swirl vanes 50 and 80 are oriented in opposing directions, such that creating opposing swirl flows are created to facilitate mixing the fuel/air mixture when the secondary airflow and the primary airflow are combined. In an alternative embodiment, primary and secondary swirl vanes 50 and 80 are oriented in the same general direction, such that a similar swirl flow is created in the fuel/air mixture.

[0017] Venturi 36 includes a substantially annular body 90 that has an inner surface 92 and an outer surface 94 that extends from an upstream end 96 of venturi 36 to a downstream end 98 of venturi 36. Venturi 36 includes a flange portion 100 positioned adjacent upstream end 96, and a throat portion 102 that extends from flange portion 100 to downstream end 98. Throat portion 102 extends substantially axially along swirler assembly axial centerline 38, and flange portion 100 extends radially outward a distance 106 from throat portion 102 such that an outer perimeter 108 of venturi flange portion 100 is generally aligned with primary swirler and secondary swirler outer perimeters 42 and 74, respectively.

[0018] In the exemplary embodiment, venturi flange portion 100 extends between primary swirler 32 and secondary swirler 34, such that venturi inner

surface 92 is coupled against primary swirl vanes 50, and such that venturi outer surface 94 is coupled against an outer surface 110 of secondary swirler inner wall 60. In an alternative embodiment, inner surface 92 is coupled against primary swirler inner wall (not shown). More specifically, in the exemplary embodiment, flange portion 100 is coupled to primary and secondary swirlers 32 and 34, respectively, by a brazing operation or a welding operation.

[0019] Venturi 36 extends downstream from primary swirler 32 such that airflow discharged from swirler 32 is channeled through venturi 36 which induces a swirling action to the airflow passing therethrough. Specifically, airflow discharged into venturi 36 is channeled by flange portion 100 into throat portion 102. Throat portion 102 has a converging-diverging cross sectional profile that extends from flange portion 100 to downstream end 98 such that a minimum throat diameter D_1 is located a distance 112 upstream from downstream end 98. Accordingly, throat diameter D_1 is smaller than a diameter D_2 of primary swirler opening 48 and is smaller than a diameter D_3 of venturi 36 at downstream end 98.

[0020] Secondary swirler 34 circumscribes venturi throat portion 102, and a portion of throat portion 102 is coupled to secondary swirler 34. Specifically, a portion 114 of venturi outer surface 94 is coupled to a portion 116 of secondary swirler inner wall outer surface 110 in a slide fit. The slide fit connection created between venturi 36 and secondary swirler 34 facilitates venturi 36 accommodating thermal expansion of secondary swirler 34, and also facilitates preventing ingestion of fuel, water and air between venturi 36 and secondary swirler 34 at downstream end 98. In an alternative embodiment, venturi downstream end 98 is coupled to secondary swirler 34 by a brazing or welding operation.

[0021] A gap 120 is partially defined between venturi outer surface 94 and secondary swirler inner wall 60. In the exemplary embodiment, gap 120 extends from venturi and secondary swirler flange portions 36 and 34, respectively, towards venturi downstream end 98 where venturi 36 and secondary swirler 34 are fixedly coupled together. Gap 120 creates a dead air cavity between venturi 36 and secondary swirler flow passage 64, which facilitates insulating venturi 36 from high

temperatures associated with flow passage 64. Accordingly, gap 120 also facilitates reducing a rate of “explosive boiling” on venturi outer surface 94, thereby minimizing the need for a ceramic coating on venturi outer surface. However, in an alternative embodiment, venturi outer surface 94 is coated with a ceramic coating. In another alternative embodiment, venturi inner and/or outer surface 92 and/or 94 is coated with a thermal barrier coating to facilitate insulating venturi 36 from high temperatures.

[0022] In the exemplary embodiment, a plurality of openings 122 extend through secondary swirler inner wall 60 to couple flow passage 64 and gap 120 in flow communication. Openings 122 enable bleed air flowing through passage 64 to enter gap 120 to facilitate providing a purge flow through gap 120. The purge flow facilitates preventing the ingestion of fuel, water and air into gap 120. In an alternative embodiment, no openings are provided between flow passage 64 and gap 120.

[0023] In the exemplary embodiment, the individual components of swirler assembly 30, such as primary swirler 32, secondary swirler 34, and venturi 36, are manufactured and fabricated from different materials to facilitate optimizing wear and performance characteristics. For example, primary swirler 32 is fabricated from a material selected to facilitate optimizing wear, and secondary swirler 34 is fabricated from a different material that is selected to facilitate optimizing thermal characteristics and bonding with venturi 36. Moreover, venturi 36 is fabricated from a material selected to facilitate optimizing wear characteristics in the presence of sprayed fuel and water and to facilitate bonding with primary and secondary swirlers 32 and 34, respectively.

[0024] During operation, the air/fuel mixture is channeled downstream through swirler assembly 30. As the mixture is channeled through primary swirler opening 48, the mixture is combined with swirling air from primary swirler 32. The swirling action facilitates spreading the mixture radially outward from swirler assembly 30 into the combustion zone. As the mixture is channeled from the swirler assembly 30, it is further mixed with air supplied by secondary swirler flow passage 64.

[0025] Figure 3 is a cross-sectional view of an alternative embodiment of a swirler assembly 130 that may be used in combination with a combustor, such as combustor 16 (shown in Figure 1). Swirler assembly 130 is substantially similar to swirler assembly 30 shown in Figure 2, and components in swirler assembly 130 that are identical to components of swirler assembly 30 are identified in Figure 3 using the same reference numerals used in Figure 2. Accordingly, swirler assembly 130 includes primary swirler 32, secondary swirler 34, and venturi 36.

[0026] Primary swirler 32 includes radially outer wall 52, a radially inner wall 140, and a radial opening 142 extending between inner and outer walls 140 and 52, respectively. Each wall 52 and 140 has an inner surface 144 and 146, respectively, an outer surface 148 and 150, respectively, and an outer perimeter 152 and 154, respectively, extending therebetween. Outer surfaces 148 and 150 face upstream, and inner surfaces 144 and 146 face downstream when primary swirler 32 is properly positioned in combustor 16. Swirl vanes 50 extend circumferentially around opening 142 and extend between outer wall 140 and inner wall 52.

[0027] Secondary swirler 34 includes inner wall 60, outer wall 62, and flow passage 64 extending therebetween. In the exemplary embodiment, secondary swirler inner wall 60 has a ridge 160 extending outwardly towards primary swirler 32, and primary swirler inner wall 52 has an upper shoulder 162 for engaging ridge 160. Swirl vanes 80 extend within flange portion 70 from inner wall inner surface 84 to outer wall inner surface 82. Flange portion 70 is in flow communication with flow passage 64 such that air is supplied to flow passage 64 through flange portion 70.

[0028] Venturi 36 includes body 90 that has inner surface 92 and outer surface 94 that extends from upstream end 96 to downstream end 98. Venturi 36 includes a flange portion 170 extending from throat portion 102 at upstream end 96. Flange portion 170 extends a distance 172 radially outward from throat portion 102 such that an outer perimeter 174 of venturi flange portion 170 is positioned between primary swirler 32 and secondary swirler 34. In the exemplary embodiment,

venturi outer perimeter 174 abuts a bottom edge 176 of ridge 160 extending from secondary swirler inner wall 60 and abuts a lower shoulder 178 of primary swirler inner wall 52. Specifically, venturi flange portion 170 is coupled against primary swirler 32 and secondary swirler 34 in a slide fit. The slide fit connection created between venturi 36 and primary and secondary swirlers 32 and 34, respectively, facilitates venturi 36 accommodating thermal expansion of swirlers 32 and 34, and also facilitates preventing ingestion of fuel, water and/or air between venturi 36 and swirlers 32 and/or 34. In an alternative embodiment, venturi flange portion 170 is coupled to primary and/or secondary swirlers 32 and/or 34, respectively, by a brazing or welding operation.

[0029] Secondary swirler 34 circumscribes venturi throat portion 102, and a portion 180 of throat portion 102 is coupled to secondary swirler 34. Specifically, venturi outer surface portion 114 is coupled to secondary swirler inner wall 60 at downstream end 98 by a brazing operation or a welding operation to facilitate preventing ingestion of fuel, water and air between venturi 36 and secondary swirler 34. In an alternative embodiment, outer surface 94 is coupled to inner wall 60 via a slide fit connection.

[0030] Gap 120 is partially defined between venturi outer surface 94 and secondary swirler inner wall 60. In the exemplary embodiment, gap 120 extends from venturi and secondary swirler flange portions 70 and 170, respectively, towards venturi downstream end 98 where venturi 36 and secondary swirler 34 are fixedly coupled together. In the exemplary embodiment, openings 122 extend between flow passage 64 and gap 120 so that flow passage 64 and gap 120 are in flow communication. In an alternative embodiment, no openings are provided between flow passage 64 and gap 120.

[0031] The above-described combustor system for a gas turbine engine is cost-effective and reliable. The combustor system includes a multi component swirler assembly that includes a primary swirler, a secondary swirler and a venturi. A dead air gap is provided between the venturi and at least one of the swirlers which facilitates cooling the venturi, and openings are provided between the

venturi and the air flow passage such that the air gap and the flow passage are in flow communication. Furthermore, because the components are slide fit together, the components facilitate allowing thermal expansion to occur therebetween. As a result, the swirler assembly facilitates extending a useful life of the combustor in a reliable and cost-effective manner.

[0032] Exemplary embodiments of swirler assemblies are described above in detail. The assemblies are not limited to the specific embodiments described herein, but rather, components of each assembly may be utilized independently and separately from other components described herein. Each swirler assembly component can also be used in combination with other swirler assembly components.

[0033] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.